Multilingual Dementia Detection through Deep Learning

Background

Alzheimer's Disease:

A neurodegenerative brain disease that reduces one's ability to complete daily tasks due to cognitive decline. It has effects on memory and general brain and bodily functions.

Statistics:

a. It is projected that there will be 150 million people with Alzheimer's Disease by 2050 (Shinkawa & Yamada, 2018)
b. It is estimated that only around 50% of people with Alzheimer's Disease are currently diagnosed (Shinkawa & Yamada, 2018)
c. Current methods involve costly or invasive procedures (MRI, PET scans, Cerebrospinal Fluid Collection) (Yang et al., 2022)
d. With the prevalence of cures such as Lecanemab that can slow disease progression by as much as 30%, diagnoses are necessary.
e. One of the key factors in Alzheimer's Disease is the loss of ability to speak over a period of time.

Machine Learning:

a. Detecting Alzheimer's disease using qualities of speech
b. Develops variables based on speech that can be used to create a model to predict Alzheimer's (repetition, word count, vocabulary level, etc.)

Deep Learning:

a. Using neural networks or large language models to analyze speech
b. Black Box
c. BERT (Bidirectional Encoder Representations from Transformers)
d. Whisper (Transcription software)

Introduction

Phrase 1:

Alzheimer's Disease and Dementia are increasingly large problems for our growing population, yet they often remain undiagnosed, and research is largely centered around English.

Phrase 2:

The goal of this project is to create a deep learning algorithm that can detect Alzheimer's Disease across multiple languages without the need for extensive training data from patients speaking a language.

Prior Studies:

- ❑ Analysis of cognitive aspects of language of indicators of Alzheimer's Disease **(Meulemans et al., 2022)**
  - ❑ Cognitive features (i.e. pauses during speech) provide a view into the brain's thinking process whilst also being something trackable across any language
- ❑ Use of a combination of wav2vec (transcription) and BERT (binary classification) to capture both cognitive and linguistic content for diagnosis **(Zhu et al., 2021)**
  - ❑ The WavBERT model created by Zhu et al. can identify abnormalities compared to standard English text, in addition to analyzing how different the actual content of the speech is compared to the pre-training data
  - ❑ A similar model is being used for this project
- ❑ Analysis of several features and their influence on diagnosis in English, Spanish, and Dutch **(Pérez-Toro et al., 2023)**
  - ❑ Came to the conclusion that diagnoses tools should be trained on the language that they are going to be diagnosed in, as detection in new languages was not optimal in their study.

Methodology:

Independent Variable:

The independent variables in this testing will be the models used to analyze Alzheimer's Disease and the language input during testing.

Materials List:

- Computer Access
- Database data (Spanish and English)
- Deep Learning Software (Anaconda, TensorFlow, etc.)

Procedure:

1. Pretraining of the model (if needed) would involve ensuring that the BERT model is trained to analyze a certain language.

2. The speech recordings were annotated to remove any instances of people other than the patient speaking. The altered recordings were inputted into an altered Whisper model. All transcripts were saved.

3. The BERT classifier model would be compiled and fitted to a majorituy of the speech transcripts generated from the whisper or wav2vec model.

4. After the BERT classifier is trained, it would be tested on the remaining speech transcripts that were not used for training (test set).

5. Accuracy was calculated, and data analysis was performed on the data (k fold validation).

Dependent Variable:

The dependent variable in this experiment will be the outputs of the model (has Alzheimer's Disease or does not have Alzheimer's Disease)

Key Questions:

- ❑ **Can a Deep Learning Model be trained in one language and be tested in another with accuracy?**
- ❑ **Can a Deep Learning Model be trained in multiple languages and diagnose in all of those languages without external tools?**
- ❑ **Does a Whisper transcription model retain enough cognitive data to diagnose Alzheimer's Disease with greater effectiveness?**

Results:

1st Model (English)

1st Model	Precision	Recall	F1	Support
0	0.5	0.5	0.5	4
1	0.5	0.5	0.5	4
Accuracy			0.5	8
macro avg	0.5	0.5	0.5	8
weighted avg	0.5	0.5	0.5	8

2nd Model (English)

2nd Model	Precision	Recall	F1	Support
0	0	0	0	7
1	0.5	1	0.67	7
Accuracy			0.5	14
macro avg	0.25	0.5	0.33	14
weighted avg	0.25	0.5	0.33	14

3rd Model (English)

3th Model	Precision	Recall	F1	Support
0	0.67	0.86	0.75	7
1	0.8	0.57	0.67	7
Accuracy			0.71	14
macro avg	0.73	0.71	0.71	14
weighted a	0.73	0.71	0.71	14

4th Model (English)

3th Model	Precision	Recall	F1	Support
0	0.67	0.86	0.75	7
1	0.8	0.57	0.67	7
Accuracy			0.71	14
macro avg	0.73	0.71	0.71	14
weighted a	0.73	0.71	0.71	14

Conclusion

Goals:

- ❑ **Accurately diagnose Alzheimer's Disease**
- ❑ **Expand Alzheimer's Disease tools to be multilingual**
- ❑ **Create a model that can diagnose in languages it has not seen yet**

Performance:

- ❑ **Model proved to be effective in detecting Dementia**
- ❑ **Models prove promising for further improvement**

Applications:

- ❑ Screening step in annual doctor's appointments (1-2 minutes max)
- ❑ Mobile or computer app
- ❑ Global testing and data collection

Future Research:

- ❑ More languages
- ❑ Different combinations of models
- ❑ Combining a deep learning approach with collection of demographic data
- ❑ Other diagnostic methods such as retinal scans

Final English Dataset:

Control	Dementia
70	70